

SOLAR/2041-79/60

## Solar Project Cost Report

HOWARD'S GROVE  
SCHOOL  
Howard's Grove, Wisconsin  
April 9, 1979



---

## U.S. Department of Energy

National Solar Heating and  
Cooling Demonstration Program

National Solar Data Program

---

## NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

This report has been reproduced directly from the best available copy.

Available from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161.

Price: Paper Copy \$4.50  
Microfiche \$3.00

SOLAR PROJECT  
COST REPORT  
for  
HOWARD'S GROVE SCHOOL  
HOWARD'S GROVE, WISCONSIN

Prepared for  
DEPARTMENT OF ENERGY  
OFFICE OF ASSISTANT SECRETARY  
FOR CONSERVATION AND SOLAR APPLICATIONS  
NATIONAL SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

UNDER CONTRACT NUMBER  
EG-77-C-01-2522

H. Jackson Hale, Solar Data Program Manager

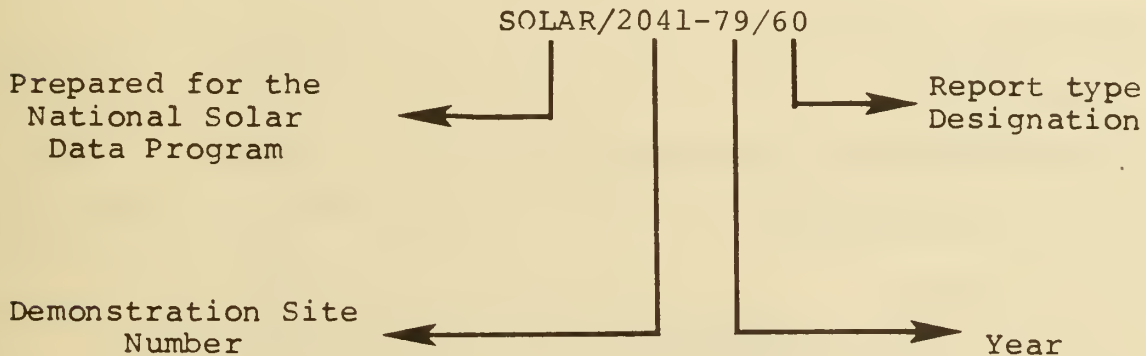
Prepared By  
MUELLER ASSOCIATES, INC.

Under Subcontract to PRC Energy Analysis Company



## NATIONAL SOLAR DATA PROGRAM REPORTS

Reports prepared for the National Solar Data Program are numbered under a specific format. For example, this report for Howard's Grove School site is designated as SOLAR/2041-79/60. The elements of this designation are explained in the following illustration:



- **Demonstration Site Number:**

Each project site has its own discrete number - 1000 through 1999 for residential sites and 2000 through 2999 for commercial sites.

- **Report Type Designation:**

This number identifies the type of report, e.g.,

- Monthly Performance Reports are designated by the numbers 01 (for January) through 12 (for December)
- Solar Energy System Performance Evaluations are designated by the number 14
- Solar Project Descriptions are designated by the number 50
- Solar Project Cost Reports are designated by the number 60

These reports are disseminated through the U.S. Department of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee 37830.

## TABLE OF CONTENTS

	<u>PAGE</u>
I. FOREWORD	I-1
II. EXECUTIVE SUMMARY	II-1
III. INTRODUCTION	III-1
IV. SYSTEM DESCRIPTION SUMMARY	IV-1
V. PROJECT BACKGROUND	V-1
VI. DATA SOURCES	VI-1
VII. COST ANALYSIS BY CATEGORY	VII-1
A. Introduction	
B. Collector Array	
C. Support Structure	
D. Piping	
E. Ductwork	
F. Insulation	
G. Heating/Cooling Equipment	
H. Storage	
I. Controls	
J. Electrical Power	
K. General Construction	
VIII. TOTAL SYSTEM CONSTRUCTION COST	VIII-1
IX. DISCUSSION	IX-1
X. SYSTEM COST FOR USE IN ANALYSIS	X-1

## I. FOREWORD

The National Program for Solar Heating and Cooling is being conducted by the Department of Energy as mandated by the Solar Heating and Cooling Demonstration Act of 1974. The overall goal of the Federal Demonstration Program is to assist in the establishment of a viable solar industry and to stimulate its growth. An analysis and synthesis of the information gathered through this program will be disseminated in site-specific reports and summary documents as part of the National Solar Data Program. This cost report is a component of a larger data gathering effort to determine the costs and cost factors to satisfy the data requirements of the following:

- DOE planning and management
- Economic projections and analysis
- The solar industry infrastructure

The focus of this report is the initial installation cost of the system. No design, start-up, operating or maintenance costs are provided nor are costs for the solar data acquisition system (SDAS) and display system that may be installed in conjunction with the solar system.

Associated reports prepared by others for this specific solar demonstration project describe the system in greater detail, provide reliability and maintenance information, and describe system performance.

A similar series of reports is being developed for other solar demonstration program projects to assure widespread dissemination of project data. Detailed analysis of this report will require reference to the "Solar Project Description" for this project, report number SOLAR/2041-79/50.





## II. EXECUTIVE SUMMARY


This report provides detailed cost information for the solar space heating project at the Howard's Grove School in Howard's Grove, Wisconsin.

This Demonstration Project was funded by the U.S. Energy Research and Development Administration (ERDA, now the U.S. Department of Energy, DOE) in the Program Opportunity Notice (PON) Cycle 2. The proposal was submitted in November 1976 and the grant was awarded in July 1977.

The system utilizes 138 Sun Stone, flat plate air collectors which provide an effective aperture area of 2,277 square feet. The collectors are mounted in 6 rows of 23 collectors on the flat roof of the building.

The 1620 cubic foot rock storage bin is partially buried under the mechanical room floor.

The construction costs of this solar space heating system are presented in this report. Category costs are listed by materials, labor, and subcontract cost. The subcontract costs include materials, labor, overhead, and profit costs for some of the support structure costs and for construction of stairs to the raised mechanical room floor. No further break down of these costs could be obtained. The construction cost for this project was \$43,165 not including construction management overhead and profit and general and administrative costs. Subsequent sections, especially Sections VI through IX, provide a more detailed account of the data base and category cost components.



Digitized by the Internet Archive  
in 2012 with funding from  
University of Florida, George A. Smathers Libraries with support from LYRASIS and the Sloan Foundation

### III. INTRODUCTION

The approach to assembling the data into solar system cost categories for every installation is to resolve the data into elements at two levels of detail, primary and secondary. Table III-1 provides an indication of the level of disaggregation associated with primary and secondary cost breakdowns.

TABLE III-1. SITE SPECIFIC COST BREAKDOWN

PRIMARY	SECONDARY
Collector Array	<ul style="list-style-type: none"> <li>• Materials</li> <li>• Delivery</li> <li>• Mounting on Support Structure</li> <li>• Collectors Connecting to Manifold</li> </ul>
Collector Support Structure	<ul style="list-style-type: none"> <li>• Materials</li> <li>• Labor</li> </ul>
Piping	<ul style="list-style-type: none"> <li>• Collector Distribution System <ul style="list-style-type: none"> <li>◦ Materials</li> <li>◦ Labor</li> </ul> </li> <li>• Other Piping <ul style="list-style-type: none"> <li>◦ Materials</li> <li>◦ Labor</li> </ul> </li> </ul>
Ductwork	<ul style="list-style-type: none"> <li>• Collector Distribution System <ul style="list-style-type: none"> <li>◦ Materials</li> <li>◦ Labor</li> </ul> </li> <li>• Other Ductwork <ul style="list-style-type: none"> <li>◦ Materials</li> <li>◦ Labor</li> </ul> </li> </ul>
Insulation	<ul style="list-style-type: none"> <li>• Collector Distribution System <ul style="list-style-type: none"> <li>◦ Materials</li> <li>◦ Labor</li> </ul> </li> <li>• Other Piping/Ductwork <ul style="list-style-type: none"> <li>◦ Materials</li> <li>◦ Labor</li> </ul> </li> </ul>
Heating/Cooling Equipment	<ul style="list-style-type: none"> <li>• Materials</li> <li>• Delivery</li> <li>• Installation</li> </ul>
Storage	<ul style="list-style-type: none"> <li>• Materials</li> <li>• Delivery</li> <li>• Installation</li> <li>• Insulation</li> </ul>
Controls	<ul style="list-style-type: none"> <li>• Materials</li> <li>• Labor</li> </ul>
Electrical	<ul style="list-style-type: none"> <li>• Total</li> </ul>
General Construction	<ul style="list-style-type: none"> <li>• Roofing</li> <li>• Equipment Room</li> <li>• Architectural</li> <li>• Excavation</li> <li>• Painting</li> </ul>
TOTAL PROJECT COST	

In general, the primary cost breakdown follows work categories typically performed by different trades or subcontractors on building systems construction projects and are often separable, identifiable costs. The secondary cost categories represent a more detailed breakdown of the primary categories and are more difficult to obtain. This information is sought through discussions with subcontractors and suppliers, and by reviewing their records.

The following are typical examples of components comprising the cost breakdown categories listed on Table III-1.

- Collector Array: all materials provided by collector manufacturer (including tracking mechanisms, attachment fittings, hoses), labor to install collectors on support structure, labor and materials to connect collectors to supply and return manifolds, and miscellaneous specialties required for a complete array.
- Collector Support Structure: all framing, beams and columns, roof connections, fasteners and brackets required to receive collectors.
- Piping: all collector distribution and major supply and return piping, external collector manifolds, if required, pumps, expansion tanks, valves, interconnecting piping, hangers, and miscellaneous piping specialties.
- Ductwork: all ductwork connecting collectors to air handling equipment, dampers, interconnection with auxiliary systems and filter boxes.
- Insulation: all insulation - both interior and exterior - for piping and ductwork, chillers, and miscellaneous equipment, except energy storage containers.
- Heating/Cooling Equipment: absorption chillers, heat pumps, or heat exchangers used to interface with auxiliary system or to deliver energy directly to load.
- Storage: vessel or container, lining, supports, pads, internal piping, nozzles, and insulation.

- Controls: solid state controllers, thermostats, alarms, switches, wiring, automatic valves and miscellaneous pneumatic or electrical devices.
- Electrical: normally an identifiable subcontract including power wiring, motor controllers, starters, conduits, disconnect switches, and miscellaneous high voltage electrical devices.
- General Construction: excavation, crane, tool and equipment rental, permits, painting, architectural modifications or additional space requirements, roofing and temporary services such as clean-up, field offices, and temporary telephone and electrical service.
- Auxiliary energy system costs are not included as part of the solar energy system costs.

Obtaining accurate total project construction cost is the focus of the data gathering effort. The costs presented do not include the contractor's overhead and profit (OH&P) or general and administrative costs. There is a general sensitivity to the publication of OH&P costs among corporations in a competitive market. Also, the bare costs (without overhead and profit) are more useful to other project planners and contractors since they could include their own overhead and profit figures.

General contractors are the main source of data since they have the most cost information for each project. Major subcontractors are interviewed where possible to obtain more specific information pertaining to respective subsystems. Interviews are pursued with the personnel from the contracting firms who were actually on site performing the work and those that kept the cost records.

For each cost category the following types of information are sought:

- Labor type utilized
- Number of workers utilized
- Number of hours required
- Time per unit of equipment installed
- Materials cost

- Labor rates
- Delivery costs of major items
- Overhead factors
- Total costs

This information is obtained from cost files, invoices, time logs, government payment request vouchers, monthly progress reports, bills-of-materials, and the interviews.

In addition to the above data, each contractor and sub-contractor is questioned concerning cost estimating techniques employed to date, recommended areas for cost reduction, final engineering cost estimates, and any other pertinent cost information.

It must be emphasized that this cost information can only be assessed in relation to the detailed system description report, Solar/2041-79/50.



#### IV. SYSTEM DESCRIPTION SUMMARY

The following is a brief summary of the Howard's Grove School solar installation. Major features of this system include:

- Collector Type - Air, flat plate
- Freeze Protection - None required
- Application - Heating
- Storage Type - Rock bin
- New/Retrofit - New
- Performance Evaluation Instrumentation - Yes

The solar energy system utilizes 2,277 square feet of Sun Stone, nonselective, flat plate collectors to supply a portion of the space heating requirements for the 12,490 square foot addition to the existing 30,000 square foot Northview school building in Howard's Grove, Wisconsin.

There are six arrays of 23 solar collector panels each on the roof of the addition. The panels are fixed in place on an aluminum framework which is attached to the roof structure with bolts. The collectors face due south and are mounted at a tilt angle of  $50^{\circ}$  from horizontal. The collectors use air as the heat transfer medium.

Solar energy is transferred to a rock storage bin located below the equipment room. The bin contains 1,620 cubic feet of washed river rock and is insulated with 3 inches of fiberglass on the sides, 1 inch of styrofoam on the bottom, and 2 inches of urethane board on the top.

Space heating is provided by circulating return air from the heated space through the solar storage bin to be heated and distributed to the classrooms. Space heating can also be accomplished indirectly from the solar system by circulating return air from the collectors along the top of the storage bin and then distributing it to the rooms. The solar ductwork is insulated with 1 1/2 inch fiberglass duct insulation on the exterior.

The auxiliary heating system consists of a 520,000 Btu/hr oil-fired boiler which provides hot water to the heat coil in the hot deck.

The solar energy system has been operational since March 1978. It has been fully instrumented for performance evaluation and integrated into the National Solar Data Network.





## V. PROJECT BACKGROUND

The Howard's Grove School solar project was constructed as a result of a PON 2 proposal to ERDA (now DOE) in November 1976. The contract with ERDA, which committed the Government to fund 60% of the project cost, was awarded in July 1977. Construction of the solar system began in September 1977 and was essentially complete by March 1978. Acceptance testing has not been completed to date.

Project responsibilities were as follows:

- Owner: School District of Howard's Grove
- Architect: Linde-Grothe Architecture
- Construction Management: Linde-Grothe Architecture
- Electrical Contractor: Schielke Electric
- Solar Panel Installation: Solar Sales
- Solar Mechanical Contractor: Household Utilities

All work, with the exception of the collector panel installation, was performed by union labor.



## VI. DATA SOURCES

Cost data for the Howard's Grove solar energy system were collected during a visit to the site made on April 9, 1979 and as a result of subsequent follow-up communications.

Cost data were collected from representatives of Linde-Grothe Architecture, Household Utilities, and Solar Sales.

The primary source materials were as follows:

- Construction Manager receipts and invoices
- Owner invoices to DOE
- Construction Manager and subcontractor accounting records of project costs
- Discussions with representatives of the various contractors



## VIII. COST ANALYSIS BY CATEGORY

### A. Introduction

In the ten sub-sections that follow, cost information is provided for the following categories of the solar system.

- Collector Array
- Support Structure
- Piping
- Ductwork
- Insulation
- Heating/Cooling Equipment
- Storage
- Controls
- Electrical Power
- General Construction

In each sub-section, descriptions of the category are presented along with the cost components. A tabular presentation of the cost data then follows. All cost data are rounded to the nearest five dollar increment. The data sources used for that category and any unique aspects are discussed along with detailed information related to the basis of the costs. This includes the identification of costs that were either unavailable or impossible to separate from the other categories.

### B. Collector Array

The collector array includes costs associated with the purchase, delivery, handling and mounting, and piping of the collectors on the structural frame. Costs associated with the materials and construction of the structural frame are included in the support structure category. For the Howard's Grove project, the collector category includes the 138 Sun Stone collector modules, end caps for the collector arrays, and mounting labor. Table VII-1 presents cost data for this category.

TABLE VII-1: COLLECTOR ARRAY CATEGORY COSTS - HOWARD'S GROVE

COMPONENT	COST, \$		
	MATERIALS	LABOR	SUBCONTRACTOR
Materials			
Collector Modules	\$21,260		None
End Caps	\$ 340		
Mount collectors		\$3,450	
Connect collectors to ductwork	N/A*		
Delivery	\$ 200		
Subtotals	\$21,800	\$3,450	None
COLLECTOR ARRAY CATEGORY TOTAL		\$25,250	

\*Data not available, typical notation in all tables. The cost of connecting the collectors to the solar ductwork could not be separated from the ductwork costs and is included in the ductwork category costs.

- Materials

- Data Source - Suppliers invoice.
- Cost Components - 138 Sun Stone collector modules.
  - Six end caps for collector rows.
  - Delivery charges.

- Labor

- Data Source - Contractor's records.
- Cost Component - Labor to hoist panels to roof manually and mount collectors to support structure.

### C. Support Structure

The Howard's Grove collector support structure consists of aluminum angle brackets connected to struts on the collectors and to angles on the roof bolted to steel plates below the roof surface. Costs for this category are presented in Table VII-2.

TABLE VII-2. SUPPORT STRUCTURE CATEGORY COSTS - HOWARD'S GROVE

COMPONENT	COST, \$		
	MATERIALS	LABOR	SUBCONTRACT
Materials			
Mounting brackets	\$1,540		
Aluminum struts	\$ 755		
Labor			
Install brackets & struts		\$1,100	
Install steel plates			\$1,380
Subtotals	\$2,295	\$1,100	\$1,380
SUPPORT STRUCTURE CATEGORY TOTAL			\$4,775

- Materials
  - Data Source - Supplier's invoice.
  - Cost Components - 102 aluminum angle brackets (supplied by the collector manufacturer).
  - 138 aluminum struts (supplied by the manufacturer).
- Labor
  - Data Source - Contractor's records.
  - Cost Components - Labor to install brackets and struts.
  - Labor and materials to install steel plates.

#### D. Piping

Since the Howard's Grove project is a solar air heating only system, no piping category costs are attributable to the solar system.

#### E. Ductwork

The ductwork category consists of all ducts and duct modifications and interfaces due to the installation of the solar system. Only the ductwork between the collectors and the storage bin is reported below. The cost of the conventional air distribution system in the building is not attributable to the solar

system, and the cost of that ductwork is not reported below. For most of the ductwork, integrally insulated fiberglass ductwork was used. Thus, insulation costs could not be separated from ductwork costs and are included below. Table VII-3 presents cost data for this category.

TABLE VII-3 DUCTWORK CATEGORY COSTS - HOWARD'S GROVE

COMPONENT	COST, \$		
	MATERIAL	LABOR	SUBCONTRACT
Ducts*	\$3,300	\$1,340	None
Blower	\$ 490	\$ 150	
Filters	\$ 10	\$ 110	
Subtotals	\$3,800	\$1,600	None
DUCTWORK CATEGORY TOTAL		\$5,400	

\*Includes some insulation costs.

- Materials

- Data Sources - Supplier's invoice, contractor's records.
- Cost Components - Insulated main solar supply and return ducts in ceiling.
  - Insulated branch supply and return ducts to roof.
  - Flexible connectors to collectors.
  - Metal shroud around branch ducts on roof.
  - 2 HP, 5460 cfm blower.
  - Filters.

- Labor

- Data Sources - Supplier's invoice, contractor's records.
- Cost Components - Labor to install solar ducts, connect collectors to ducts, install blower and filters, and construct metal shroud around branch supply and return ducts on roof.



## F. Insulation

The insulation category includes all insulation used in the solar system except that employed in the solar collectors and for the storage bin. Most ductwork insulation costs could not be separated from ductwork costs and are included in that category. Costs for insulation around the ductwork on the roof are presented in Table VII-4.

TABLE VII-4. INSULATION CATEGORY COSTS - HOWARD'S GROVE

COMPONENT	COST, \$	
	MATERIALS	LABOR
Material	\$320	
Labor		\$430
Subtotals	\$320	\$430
INSULATION CATEGORY TOTAL		\$750

- Materials
  - Data Sources - Contractor's records.
  - Cost Component - Glass-fiber insulation installed between flexible inlet and outlet ducts to each of six collector rows and protective color clad shrouds.
- Labor
  - Data Sources - Contractor's records.
  - Cost Component - Labor to install glass-fiber insulation around flexible ducts above roof.  
28 man-hours @ \$15.43/hr.

## G. Heating/ Cooling Equipment

No heating/cooling equipment category costs are attributable to the solar system at Howard's Grove.

## H. Storage

The storage category consists of materials and labor to install and insulate the rock storage bin. Costs for this category are presented in Table VII-5.

TABLE VII-5. STORAGE CATEGORY COSTS - HOWARD'S GROVE

COMPONENT	COST, \$		
	MATERIALS	LABOR	SUBCONTRACT
Materials	\$3,000		None
Installation		\$1,400	
Insulation	\$ 400	\$ 200	
Delivery	N/A		
SUBTOTALS	\$3,400	\$1,600	None
STORAGE CATEGORY TOTAL		\$5,000	

- Materials
  - Data Source - Contractor's records.
  - Cost Components - Materials to construct concrete block rock storage bin.
- Labor
  - Data Source - Contractor's records.
  - Cost Components - Construction of rock bin.
- Insulation
  - Data Source - Contractor's records.
  - Cost Components - Rigid glass-fiber insulation.

## I. Controls

The controls category includes all equipment in the system installed for the purpose of automatically regulating system operation. Some labor on the controls category is included in the electrical category costs because the electrician's costs could not be broken down. Table VII-6 presents controls cost data.

TABLE VII-6. CONTROLS CATEGORY COSTS - HOWARD'S GROVE

COMPONENT	COST, \$		
	MATERIALS	LABOR	SUBCONTRACT
Motorized dampers	\$1,030	\$600	None
Control unit	\$ 130		
Subtotals	\$1,160	\$600	None
CONTROLS CATEGORY TOTAL		\$1,760	

- Materials
  - Data Sources - Contractor's records.
  - Cost Components - Six sets of motorized dampers.
  - Control unit for blower.
- Labor
  - Data Sources - Contractor's records.
  - Cost Components - Labor to install six motorized dampers.

#### J. Electrical Power

The electrical power category includes all components, materials and labor required to install the power distribution system for the electrical energy needed for the system. For the Howard's Grove system, labor to install part of the control system could not be separated from the electrical power labor and is included below in the electrical power category costs. Table VII-7 presents electrical power category costs.

TABLE VII-7. ELECTRICAL POWER CATEGORY COSTS - HOWARD'S GROVE

COMPONENT	COST, \$		
	MATERIALS	LABOR	SUBCONTRACT
Wiring to blower and dampers	\$50	\$80	None
Subtotals	\$50	\$80	None
ELECTRICAL POWER CATEGORY TOTAL		\$130	

- Materials
  - Data Sources - Contractor's records.
  - Cost Components - Materials for wiring to blowers and motorized dampers.
- Labor
  - Data Sources - Contractor's records.
  - Cost components - Labor for wiring to blowers and motorized dampers.

#### K. General Construction

The general construction category includes all materials and labor consumed in the project but not directly attributable to any of the solar energy system categories. At Howard's Grove, the floor of the mechanical room is raised because the rock storage bin is below the room. The cost of steps leading to this raised floor is included in the general construction category. See Table VII-8 for general construction category costs.

TABLE VII-8. GENERAL CONSTRUCTION CATEGORY COSTS - HOWARD'S GROVE

COMPONENT	COST, \$		
	MATERIALS	LABOR	SUBCONTRACT
Stairs to mechanical room	None	None	\$100
Subtotals	None	None	\$100
GENERAL CONSTRUCTION CATEGORY TOTAL			\$100

- Subcontract
  - Data Sources - Contractor's records.
  - Cost Components - Labor and materials to construct stairs to the mechanical room.

## VIII. TOTAL SYSTEM CONSTRUCTION COST

Table VIII-1 presents the total system construction cost summary based on costs presented in Section VII. For clarity, attention is called to the fact that the materials and labor columns include the cost of materials and equipment, and direct-labor. No allowance for overhead and profit (OH&P) or general and administrative expenses (G&A) has been made. Charges for OH&P and G&A can vary significantly and are primarily important to the individual firms and specific project. Applying such charges to the data presented in Table VIII-1 is a straightforward matter and is discussed further in Section X.

The subcontract column of Table VIII-1 includes the OH&P of the subcontractor. It was not possible to exclude the OH&P values from this column.

TABLE VIII-1. TOTAL SYSTEM CONSTRUCTION COST SUMMARY  
HOWARD'S GROVE

CATEGORY <sup>a</sup>	MATERIALS	LABOR	SUBCONTRACTS	TOTAL
Collectors	\$21,800	\$3,450	None	\$25,250
Support Structure	\$ 2,295	\$1,100	\$1,380	\$ 4,775
Piping	None	None	None	None
Ductwork <sup>b</sup>	\$ 3,800	\$1,600	None	\$ 5,400
Insulation <sup>b</sup>	\$ 320	\$ 430	None	\$ 750
Heating/Cooling Equipment	None	None	None	None
Storage	\$ 3,400	\$1,600	None	\$ 5,000
Controls <sup>c</sup>	\$ 1,160	\$ 600	None	\$ 1,760
Electrical Power <sup>c</sup>	\$ 50	\$ 80	None	\$ 130
General Construction	None	None	\$ 100	\$ 100
Subtotals	\$32,825	\$8,860	\$1,480	\$43,165 <sup>d</sup>
TOTAL MATERIALS, LABOR AND SUBCONTRACT			\$43,165 <sup>d</sup>	

<sup>a</sup>For a complete description of items included in each category, see Section VII.

<sup>b</sup>Some insulation costs are included in the ductwork category.

<sup>c</sup>Some controls costs are included in the electrical power category.

<sup>d</sup>Does not include overhead and profit or general and administrative expenses.



## IX. DISCUSSION

In this section, the data are presented in formats to facilitate comparisons and further analysis of data collected at the various demonstration sites.

In Section VII, several factors affecting the representativeness of a given category's cost data are discussed. A useful method of comparing systems is to analyze the proportional composition of the total cost. It is also useful to analyze the cost data unitized by some system parameter such as collector aperture area. Table IX-1 presents the proportional composition of the total system cost and the unit category costs.

TABLE IX-1. CATEGORY COSTS PER UNIT AREA AND AS A PERCENT OF TOTAL COST -  
HOWARD'S GROVE  
(BASED ON 2,277 Sq. Ft. AREA)

CATEGORY <sup>a</sup>	UNIT COST, \$/ft <sup>2</sup> COLLECTOR AREA <sup>c</sup>		PERCENT OF TOTAL SYSTEM COST	
	BARE COSTS \$/ft <sup>2</sup>	TOTAL COSTS INCLUDING (OH&P) <sup>b</sup> \$/ft <sup>2</sup>	% TOTAL	% TOTAL (OH&P)
Collector Array	\$11.10	\$13.90	58	59
Support Structure	2.10	2.50	11	11
Piping	None	None	None	None
Ductwork	2.40	3.00	13	13
Insulation	0.30	0.40	2	2
Heating/Cooling Equipment	None	None	None	None
Storage	2.20 <sup>d</sup>	2.70	12	11
Controls	0.80	1.00	4	4
Electrical Power	0.10	0.10	<1	<1
General Construction	0.10	0.10	<1	<1
TOTAL SYSTEM	\$19.00	\$23.60	100	100

<sup>a</sup>For complete description of items included in each category, see Section VII.

<sup>b</sup>See Section X for the procedure used to add overhead and profit.

<sup>c</sup>Costs in 1977 dollars, rounded to nearest \$0.10.

<sup>d</sup>Equates to \$50/ton storage capacity.





## X. SYSTEM COST FOR USE IN ANALYSIS

Detailed performance data is being acquired for this solar energy system through the National Solar Data Network. The assessment of this system's economic performance (cost/MMBtu) requires a total construction cost figure that should include an overhead and profit (OH&P) factor. However, a constant OH&P factor will be applied to all bare costs in these reports to remove the effect of the great variation of OH&P percentages encountered in the program.

To illustrate the problem, consider two systems. System A performs well, but was installed by a contractor with a high OH&P factor. System B does not perform as well, but was installed by a contractor with a low OH&P factor. It would not be appropriate to penalize System A in an economic performance comparison of the two systems because of the installers OH&P factor. Major variations in OH&P factors are expected due to the diversity of business firm types that contracted to install the solar demonstration systems. These include colleges and universities, engineering firms and construction contractors. The comparison discussed above represents the extremes of conditions that can be encountered.

As a result, a need exists to "normalize" the treatment of OH&P in analysis of the cost data. For this reason, an OH&P factor of 25% will be added to all bare costs (materials and labor) and 10% will be added to all subcontract costs to represent the cost that the General Contractor would charge for the system.

The equivalent total construction cost thus determined for the solar energy system in the Howard's Grove School is \$53,735 in 1977 dollars. To allow equivalent comparisons among sites, all cost data must account for the effects of inflation. Adjustment of data from all sites to a common year will eliminate inflation biases. The year selected was 1977, thus no escalation factor is needed, since the Howard's Grove system was constructed in 1977.

Table X-1 lists the system total cost figures in absolute dollars and in dollars per square foot of collector area with and without the OH&P.

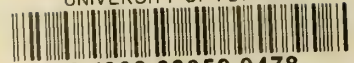
TABLE X-1. SUMMARY OF TOTAL COST FIGURES PRESENTED IN REPORT

TOTAL COST	TOTAL WITHOUT OVERHEAD AND PROFIT	TOTAL WITH OVERHEAD AND PROFIT
	\$43,165	\$53,735
\$/Sq. Ft.*	\$19.00/ft <sup>2</sup>	\$23.60/ft <sup>2</sup>

\*Based on 2,277 sq. ft. collector area.



UNIVERSITY OF FLORIDA



3 1262 09052 0478